TAUT-WIRE, SUN-AZIMUTH TRAVERSES

by

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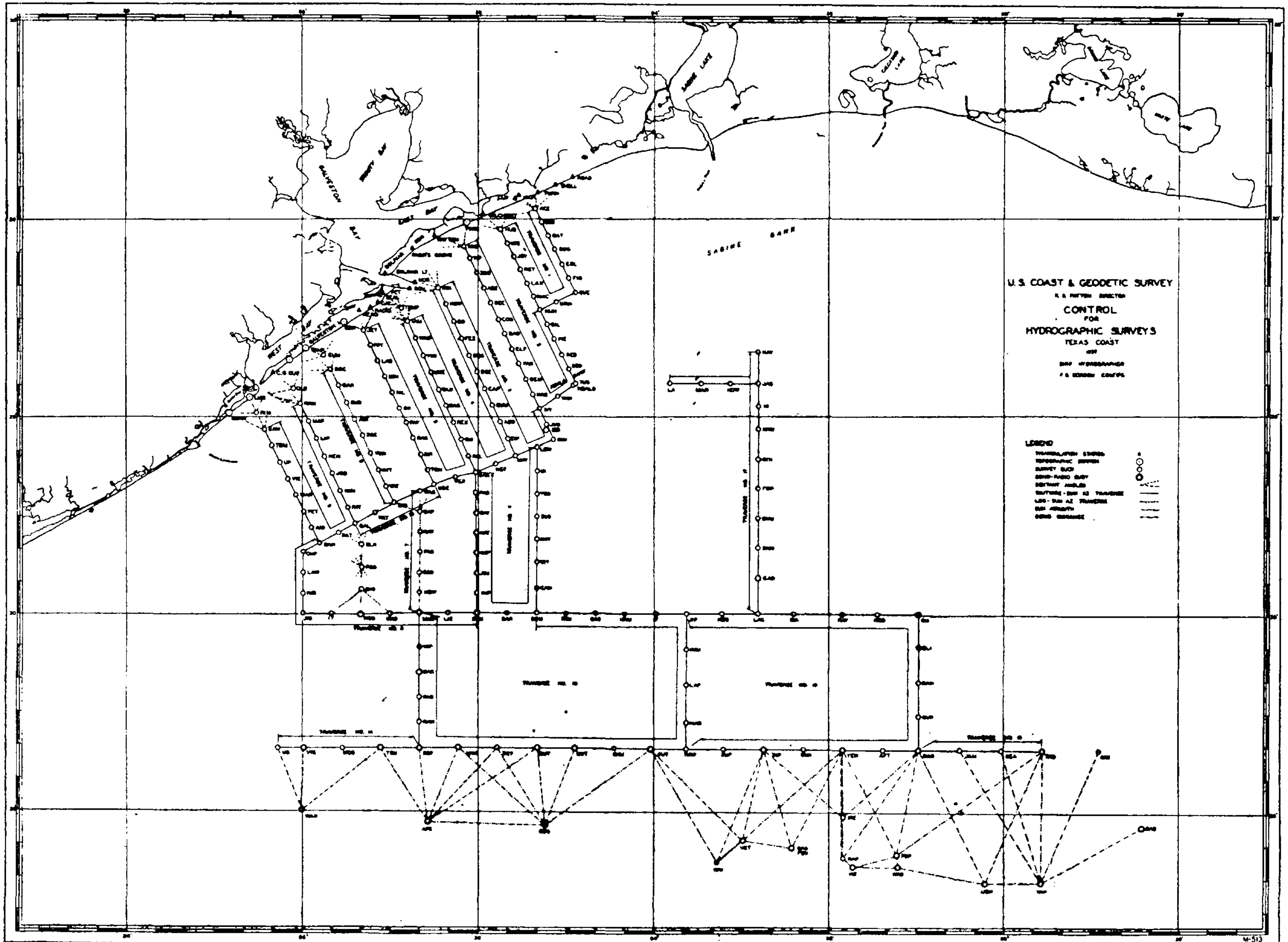
Three seasons' experience on the Atlantic and Gulf Coast during which more than 1200 miles of taut-wire, sun-azimuth traverses were run by the writer has shown by the thirty-odd loop closures that an accuracy of at least one part in 1000 can be expected in this class of work. The traverses run during the past season (1938) by the Ship *Oceanographer* are shown on the sketch opposite.

During the three seasons referred to, traverse buoys have been anchored, or as we say, « planted » in depths ranging from 5 to 42 fathoms, usually with a two to one scope and using three railroad car couplers for a single anchor. The spacing of buoys in the traverses has ranged from 2-1/2 to 6-1/2 miles. The shorter intervals are used where visual fix hydrography is contemplated, or where, because of prevailing haze, there is a probability of low visibility at the time the azimuth observations are made. Higher accuracy and a considerable saving in time result from taking the azimuth observations at the same time the taut-wire measurement is made, so it is well to allow a visibility factor of safety when establishing buoys for any section of a traverse, the general azimuth of which will permit simultaneous distance and azimuth measurements. It takes but little extra time to plant and pick up a few extra buoys, but missing an azimuth because of low visibility upsets the general plan of procedure, delays availability of a limited number of buoys for new traverse, and impairs the excellent coordination of buoy positions that is obtained when both azimuth observations and distance measurements are made during one full speed run of the ship. In general, the distance between buoys is increased when clear weather prevails ; when visual fix hydrography is not contemplated ; where the primary purpose is to extend the control scheme ; and where the general azimuth of a traverse section is so near east and west that it appears unlikely the azimuths and distances can be obtained simultaneously. Also, on traverse sections in deep water, where long anchor cables are required, it is often necessary to increase the spacing more than would be desirable if there were an unlimited supply of anchor equipment available.

When planning a traverse control scheme, it is well to avoid planting a row of buoys in an east-west direction in so far as practicable. Unless one is fortunate enough to find another vessel on the horizon on which to split angles, the chances are, due to the steepness of the inclined angle, that satisfactory azimuths cannot be obtained throughout the taut-wire line or even on a subsequent full speed run along the line of buoys. Generally the determination of azimuths on east and west lines becomes a tedious operation, and may require a supplemental target buoy some distance off the traverse line for splitting the inclined angles. In general, the nearer the azimuth of a row of buoys is to the meridian the better are the chances of carrying azimuths through the entire section on one run of the ship.

The question has arisen as to whether an attempt should be made to correct buoy positions on traverses for the scope of the anchor cable. During the past season this was not done, and the loop closures showed an average error in the traverses of 1.3 meters per mile (0.8 meter per kilometer). Experience shows that the several adjacent buoys of a traverse section usually are veering to their anchors in nearly the same directions, and with practically the same intensity of current, and the effect of scope differential between buoys in coastal shelf waters is negligible. During the previous season in the Gulf of Mexico where conditions were more favorable for this class of work, the corrections were made and the average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error was 1.0 meter per mile (0.6 meter per kilometer). Provided the method is employed, wherever possible, of observing azimuth when the taut-wiring is done, I am of the opinion that corrections for scope are unwarranted, when plotting on scales of 1: 40,000 or smaller, except in localities where it is apparent that a radical change in the current occurs while a section of the traverse is being measured. This statement, of course, does not apply to the starting buoy or to the tie-in buoy. Each of these should be related to its respective anchor and the positions of the anchors considered as the two fixed ends of the traverse. In locating these buoys, the method of range intersections, in which fixes are taken with the buoy in range with each of three or four shore signals, is recommended.

Experience also indicates that errors considerably larger than those caused by the uncertainty of buoy scope are apt to result from blunders and errors made in obtaining, recording and computing the traverse data. Only a trained organization and one in which each member exercises the greatest care can expect to obtain and record accurately all of the distance, azimuth and sounding data required for computing the traverse and plotting the sounding line, and obtain this information within the period of time it takes for the ship to make the run at about 10 knots speed. For this reason certain supplemental data that may be helpful in isolating blunders or eliminating uncertainties should be obtained. To my knowledge, mistakes of one degree have been spotted on two occasions by having available the gyro compass bearings taken of each buoy range as the traverse was measured. On another occasion, an appreciable error in distance was discovered by having available the log distances as a check to the taut-wire distances.

To avoid dragging the anchor at the end of the taut wire after the traverse is started, and to assure uniform conditions over the traverse the anchor should be dropped at least one-half and preferably three-fourths of a mile before reaching the first buoy. On the *Oceanographer,* a 70- pound sounding shot is used as the anchor. This is dropped with the vessel proceeding along the range of the first pair of buoys at slow speed. The speed should be increased gradually and it is a safe precaution not to attempt to attain full speed until the second buoy is reached. If the traverse line is also a sounding line, log readings should be recorded at sufficient intervals to insure that increasing the speed does not result in improper spacing of soundings. With the *Oceanographer,* the speed was generally increased to about 7 knots by the time the first buoy was reached and then increased to 9 or 10 knots at the time of passing the second buoy. While it appears that the taut-wire device will stand a speed of about 12 knots, a speed of about 10 knots gives much smoother operating conditions and reduces strain on the wire and anchor. Pilothouse control of the engines is a decided advantage for making a uniform increase in speed.

Taut-wire sheave readings at buoys should be made by two officers and the reduction of revolutions to meters carefully checked and initialed. After the readings have been made, at least one of these officers becomes available to assist with sun-azimuth observations, which are taken as soon as the ship is placed on the next range ahead or astern as the case may be. The stand-by signals from the bridge, which also serve to inform the officers aft at the taut-wire apparatus on which side a buoy will be passed are made with the ship's whistle, and are the same as used for passing vessels except that the signals are made shorter. In case there are other ships in the vicinity, this information is sent to the taut-wire observers by messenger.

Compass bearings of each buoy range should be observed both when planting buoys and when observing the sun-azimuths. The bearings are helpful, not only for picking up errors but they also afford an excellent means of checking the compass by a comparison with the corresponding sun-azimuths. Such comparisons have indicated that bearings on a gyro repeater can be obtained with an accuracy of one or two tenths of a degree. This, however, cannot be considered a measure of the absolute accuracy of the gyro compass because of the oscillations set up in the gyro compass when making turns. Gyro compass bearings taken when the ship is running the traverse are usually more reliable than those taken when planting the buoys because in the former, a uniform speed is maintained with only small variations in course.

In addition to recording log readings at each buoy, the distance the ship passes abeam of the buoy as well as the direction of the current should be recorded. This latter is obtained by taking a bearing on the target buoy when it comes on range with the relieving or watch buoy. Much of this information may not be used but some of it is certain to be found useful at a later date.

At least three observations should be made of the inclined and vertical angles for each sun-azimuth, and special care should be taken to check the *degrees* of the inclined angle reading. The angles are generally observed in rapid succession in order to obtain them all before the ship moves off the range or the sun goes behind a cloud or under the horizon, and it is quite possible that a mistake in the degrees may be carried through the entire series.

A radio time comparison should be obtained on the day the traverse is measured and, needless to say, particular care is required on the part of the recorder to mark the times correctly and record the corresponding angles. As previously stated, the inclined and vertical angles are generally obtained in rapid succession and unless a recorder experienced in this class of work is available he should have assistance until he becomes experienced. It is essential that the angles and all other data be called out to the recorder distinctly and uniformly but not too rapidly.

When contemplating both distance and azimuth measurements on one run of the ship, the buoys should be anchored so as to avoid large differences in the azimuths of adjacent buoy ranges. If this occurs, it will not be possible to obtain the sun-azimuths while making the run without having an appreciable curve in the taut-wire line between buoys because of the wide swing necessary to put the ship on range with the next pair of buoys in time to make the series of azimuth observations. When planting a row of buoys, it is well to watch carefully the bearing of the last buoy planted, and to con the ship so that it will be on the desired azimuth when the log distance to the proposed position of the next buoy has been run, rather than to attempt to maneuver the ship after the approximate position has been reached. By watching the back bearing of a buoy as well as its relationship to its own relieving buoy, a fair estimate can be made of the strength of the current setting across the course. Allowance can then be made for the drift of the ship during the time it takes to plant the buoy as well as for the buoy scope when it swings to its anchor.

In planting buoys, the buoy itself is first put in the water and the ship is then backed away until the cable has been straightened out before the anchor is dropped. For this reason, it is not desirable to plant a buoy, particularly a sono-radio buoy, with the vessel headed directly into the current since the cable may foul the anchor, or the hydrophone foul the anchor cable, while the target buoy is assuming its natural position with relation to the anchor. For want of better information when planting a buoy, and in regions where wind currents prevail, one can usually assume that the current is setting approximately 20° to the right of the wind.

When running a traverse, the buoys should be passed on the side opposite that from which the current is setting, as indicated by the relationship between the target and relieving buoys. This is not only safer but it makes it possible to pass close to the buoy and thus avoid any appreciable departure from the range. When passing the next to the last buoy a bearing should be taken on the buoy ahead and the ship conned so as to maintain this bearing until the last buoy is reached.

The question has arisen as to how sharp a turn can be made at a buoy without appreciable error in the distance measurement due to straightening out of the wire. It has been observed on two occasions that the resistance of the water to the side pull of taut-wire, when changing course sharply at a buoy, is much greater than expected and it is my opinion that, in so far as the side pull of the wire is concerned, very little, if any error in distance results from making turns as large as 18°. Sometimes it is practicable to pass a buoy on the outside of a sharp turn which insures that if the wire does pull sidewise to any great extent, it will be stopped by the buoy cable. Of course, this should not be done in the case of sono-radio buoys as the taut-wire may foul the hydrophone cable.

Several methods of determination of buoy positions have been used during the three-year period referred to. The graphical method of plotting on aluminum sheets was not used during 1938 on this party except for the location of tie-in buoys. Of the several methods of computing traverses, the standard method used in computing geodetic positions on a shore traverse was used during the past season and is, in my opinion, the most satisfactory. Computations are made independently by two officers on form N° 596 (Position Computation, Traverse) and the closing error is distributed back through the traverse in proportion to the distance run.

Occasionally the moon or a planet has been used to advantage for azimuths when the sun has not been available. On September 9, 1938, only one set of observations could be obtained on the sun before it went below the horizon. However, both the moon and Jupiter were showing in favorable positions and were used. The resulting azimuths of the buoy range as determined from the sun, moon and Jupiter differed by less than 4 minutes. The question has arisen in connection with the use of the moon on this class of work as to whether the correction for horizontal parallax should be applied. Since the observer, the center of the moon and the center of the earth are in the same vertical plane, it is apparent that the distance of the observer from the center of the earth would have no effect on the azimuth of the moon. Consequently the correction for horizontal parallax need not be considered in the computation of azimuths based on angles taken between buoy ranges and the moon.

With an experienced organization the personnel normally available on each watch, when engaged on other classes of work, is adequate for running a taut-wire, sun-azimuth traverse except that an additional man is required to operate the taut-wire machine. The organization then consists of three officers, one recorder, one quartermaster, helmsman and a petty officer at the taut-wire apparatus. If sounding the traverse line also it is well to have an additional recorder.

The officer in charge of the watch places the ship on the first range and, when at the proper distance from the first buoy and with the ship at slow speed, signals one short blast of the whistle to drop the taut-wire anchor. He then cons the ship on the range, gradually increasing the speed, obtains current direction at the buoys, distances passed from the buoys, keeps up the abstract and in addition is in full charge of all operations. Generally he also measures the inclined angle.

The other two officers divide their time between the taut-wire machine and the bridge. They record and check the taut-wire sheave readings and compute and check the distances in meters between buoys. On the bridge they enter and copy check the distances on the abstract, measure vertical angles, observe gyro compass bearings of ranges, determine and enter positions of the sun-azimuths and, if time is available, start the azimuth computations.

If soundings are not taken on the traverse line, the recorder enters the times and angles on the azimuth form and records the electric log reading at each buoy. If soundings are taken the recorder devotes his entire time to the fathometer and sounding record and additional help is needed for recording the azimuth data.